Anatomical Features of the Dipterocarp Timbers of Sarawak

by

F. CHU FEI-TAN

Forest Department, Sarawak.*

Summary

Economically, the family Dipterocarpaceae is one of the most important in Malaysia, producing timber and other commodities.

The timber of some 200 species of dipterocarps indigenous to Sarawak has been anatomically examined and found to conform to about a dozen homogeneous groupings corresponding, in the main, to generic categories. The characteristics of these categories are described in detail and summarised in tabular form. Anatomical relationships between the groupings are discussed and attention is directed to similarities and differences between them. Also, indicative specific gravities for the 200 species examined have been listed.

A key to the timber groupings, which have commercial application, has been prepared.

Introduction

About two-thirds of the total area of Sarawak is occupied by forests. Browne (1955) has remarked upon the fact that, although these forests may contain as many as 3,000 different species, they are dominated by the Dipterocarpaceae. This family of commercially valuable trees is, with the exception of the sub-family Monotoideae which occurs only in Africa, confined to the Indo-Malaysian region where the timber is used locally for many purposes and is an important component of the nation's overseas trade. In addition, these trees furnish dammar (amber) used in the manufacture of varnish and an oil which is used in foodstuffs, medicines and cosmetics. This oil is obtained from illipe nuts — the fruits of the Engkabang (*Shorea* spp.) trees.

Over 200 species of Dipterocarpaceae have been recognised from Sarawak but, for commercial purposes, these fall into about a dozen categories corresponding, in the main, to generic groupings. The appearance and properties of many of the timbers within the family are very similar and the differences between the several groupings are not always easy to recognise.

Desch (1957) has described the gross structure of the dipterocarp timbers of West Malaysia. Metcalfe and Chalk (1950) have summarised the anatomical features of all the genera within the family but make little reference to specific differences within each genus. This paper presents the results of an intensive study of specific variation in the 9 genera of dipterocarp indigenous to Sarawak. The results of this study have been summarised in the form of two tables, one dealing with the anatomical features characteristic of each genus, the other setting out the densities of the 200 species examined. In addition, a key for the separation of the various timber groupings recognised by the timber trade has been prepared.

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* Current affiliation: Timber Office, Department of Trade, Singapore.

In the text, genera have been described in alphabetical order, regardless of natural affinities. Field characteristics have been summarised from descriptions published by Browne (1955) or Ashton (1964). The technical description of the wood structure conforms to the usage of the International Association of Wood Anatomists (1957). The density classification proposed by Kauman and Kloot (1968) has been accepted as conforming sufficiently closely to commercial differences in the dipterocarp timbers.

A projection microscope and superimposed scale (designed by F.P.R.L., Princes Risborough, U.K.) were used to measure the sizes of pores/vessels and rays, and the sizes quoted conform to the system of the British Forest Products Research Laboratory (1960). Hardness was determined subjectively, by shaving the end-grain with a pocket knife, the rating being: —

soft, moderately hard, hard and *very hard.*

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KEY TO THE DIPTEROCARP TIMBERS OF SARAWAK

1 (a) Pores exclusively solitary 2
(b) Pores not exclusively solitary 7

2 (a) Wood distinctly yellow .... MERSAWA (*Anisoptera* spp.)
(b) Wood not yellow 3

3 (a) Axial intercellular canals in long tangential series .... KAPUR (*Dryobalanops* spp.)
(b) Axial intercellular canals not in long tangential series 4

4 (a) Axial intercellular canals diffuse; wood texture fine 5
(b) Axial intercellular canals in short tangential series; wood texture coarse .... KERUING (*Dipterocarpus* spp.)

5 (a) Pores numerous to very numerous 6
(b) Pores moderately few .... PENYAU (*Upuna borneensis*)

6 (a) Silica present .... RESAK (*Cotylelobium* spp.)
(b) Silica absent .... RESAK (*Vatica* spp.)

7 (a) Crystals in parenchyma, chambered, usually in long strands .... WHITE SERAYA (*Parashorea* spp.)
(b) Crystals in parenchyma, not chambered, usually not in long strands 8

8 (a) Wood below 60 lb. per cu. ft. air-dry 9
(b) Wood over 60 lb. per cu. ft. air-dry 14

9 (a) Pores in characteristic groups of 3–5; silica present .... WHITE MERANTI (*Shorea* spp.)
(b) Pores not in groups of 3–5; silica absent 10

10 (a) Wood texture fine .... SELANGAN (*Hopea* spp.)
(b) Wood texture coarse 11

11 (a) Wood yellow; radial intercellular canals always present; rays bright yellow (transverse section) .... YELLOW MERANTI (*Shorea* spp.)
(b) Wood not yellow; radial intercellular canals present only in a few species of Red Meranti; rays not bright yellow 12

12 (a) Wood parenchyma prominent, tending to short lines between rays; axial intercellular canals prominent on all surfaces 13
(b) Wood parenchyma not prominent; axial intercellular canals distinct on all surfaces but not prominent .... LIGHT RED MERANTI (*Shorea* spp.)

13 (a) End cut glistening or waxy .... RED SELANGAN (*Shorea* spp.)
(b) End cut dull .... DARK RED MERANTI (*Shorea* spp.)

14 (a) Diameter of axial intercellular canals considerably smaller than that of vessels; wood texture coarse .... SELANGAN BATU (*Shorea* spp.)
(b) Diameter of axial intercellular canals often as large or larger than that of vessels; wood texture fine .... GIAM (*Hopea* spp.)

SUMMARY OF QUANTITATIVE VALUES

DENSITY CLASSES (see Kauman & Kloot, 1968)

Light	< 30 lb. per cu. ft.
Medium	30 — 45 lb. per cu. ft.
Heavy	45 — 60 lb. per cu. ft.
Very heavy	> 60 lb. per cu. ft.

PORE NUMBER (see F.P.R.L., Princes Risborough, 1960)

Very few	< 12 per 10 mm^2
Few	12 — 30 per 10 mm^2
Moderately few	30 — 65 per 10 mm^2
Moderately numerous	65 — 125 per 10 mm^2
Numerous	125 — 250 per 10 mm^2
Very numerous	> 250 per 10 mm^2

PORE and RAY SIZE (see F.P.R.L., Princes Risborough, 1960)

Size	Vessel Diameter — Tangential		Ray Width (Transverse section)	
	Microns		Microns	
2	< 50	Very small		
3	50 — 100	Moderately small	> 50	Fine
4	100 — 200	Medium	50 — 100	Medium
5	200 — 300	Moderately large	100 — 200	Moderately broad
6	> 300	Very large	200 — 400	Very broad

Anisoptera

FIELD CHARACTERISTICS

Of the five species of *Anisoptera* (Mersawa) known to occur in Sarawak, two are rare and of no commercial importance. Of the other three species *A. grossivenia* is the most common but not enough to rate the genus as important a timber source as it is in the forests of northern West Malaysia, Thailand and Indo-China. Commercial stands of this species and of *A. laevis* are found in the lowland forests whereas *A. marginata* is restricted to peat swamp forests. The genus usually occurs on yellow sandy soils, calcareous shales or sandstone hills and on peat. All species develop into medium to large-sized trees, maximum height between 150–180 feet, with a girth of about 15–18 feet, with straight, cylindrical boles. Buttresses are prominent, thick and rounded. Bark surface is dull brown, dotted with warty lenticels, rather irregularly fissured. Dammar (amber) exuding from surface fissures appears as smears on the bole.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, with a few radial, tangential and oblique pairs, uniformly distributed, moderately numerous, generally oval, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, as incomplete sheaths to the vessels, occasionally aliform; apotracheal, diffuse and in short uniseriate bands between rays, the uniseriate bands being most distinct and numerous in *A. laevis*; around the axial intercellular canals, sometimes forming more or less continuous tangential layers.

Rays. Mostly 2–7 cells wide (medium-sized), uniseriates (fine) short and rare, less than 2 mm. in height; heterogeneous (Kribs's types III and II) with 1–3 marginal rows of square or upright cells.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls thick. Cells intermediate between vasicentric tracheids and fibre-tracheids occur in the immediate proximity of the vessels.

Intercellular Canals. Axial canals scattered singly and in pairs throughout the fibres, sometimes in more or less continuous tangential rows; diameter usually less than that of the vessels; canals commonly blocked with chalky deposits.

Crystals. Wanting.

Silica. Abundant in all species in ray cells, occasionally in parenchyma.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood fairly distinct, pale yellow; about 2 inches wide.

Heartwood yellow, later darkening to yellow-brown.

The timber is moderately hard and medium to heavy, with an average density of 47 lb. per cu. ft. (range: 42–56 lb. per cu. ft.) air-dry.

Grain shallowly to rather deeply interlocked; texture moderately coarse, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals distinguishes this timber from non-dipterocarps.

(ii) The diffuse axial canals preclude the possibility of confusing this timber with other dipterocarp timbers except Keruing (*Dipterocarpus* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and Penyau (*Upuna borneensis*).

(iii) The timber can be separated from Keruing, Resak and Penyau by its distinctive yellow colour. Further, the timber of *Anisoptera* is much coarser in texture, and less hard, than Resak and Penyau.

Cotylelobium

FIELD CHARACTERISTICS

Three species of this genus are known to occur in Sarawak on a variety of soils on sandstone ridges and limestone hills. In Sarawak, all species of *Cotylelobium* and *Vatica* are collectively known as Resak, although as trees, the two genera are quite distinct in many of their characters. All species of *Cotylelobium* grow to medium-sized trees, with a maximum height of 120–140 feet and a girth of 8–12 feet. Frequently, the trees have twisted boles, with low and rounded buttresses, similar to *Vatica*. Bark surface is at first smooth, greyish and hoop-marked, becoming irregularly, shaggily flaked with age. Creamy or yellow smears of dammar present on the bole.

WOOD ANATOMY

Pores/Vessels. Exclusively solitary, generally round, numerous, moderately small to medium-sized (size 3–4); intervascular pitting rare, alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, usually as incomplete borders to the vessels, abaxially aliform, occasionally confluent; diffuse and diffuse-in-aggregates, sometimes tending to short, uniseriate bands between rays; also around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present in *C. burckii*) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and sometimes in pairs throughout the fibres, diameter less than that of the larger vessels but as large as some of the smaller; canals commonly blocked with chalky deposits.

Crystals. Wanting.

Silica. Present in ray cells of all species, occasionally in parenchyma but rarely in fibres.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood yellow-brown and distinct from heartwood; about ½–1 inch wide.

Heartwood red-brown when freshly sawn, later darkening to dark brown.

The timber is very hard and very heavy, with an average density of 64 lb. per cu. ft. (range: 58–67 lb. per cu. ft.) air-dry.

Grain straight or shallowly interlocked; texture fine and even.

DISTINGUISHING FEATURES

(i) The timber of *Cotylelobium* and *Vatica* are so similar in appearance and properties that the common name Resak is used for both. They may be recognised as dipterocarps by the presence of axial intercellular canals and separated by the presence of silica which is abundant in the ray cells of *Cotylelobium* but absent from *Vatica*.

(ii) By the arrangement of its diffuse axial canals, this timber is readily distinguished from Kapur (*Dryobalanops* spp.), Selangan Batu and all Merantis (*Shorea* spp.), Selangan and Giam (*Hopea* spp.) and White Seraya (*Parashorea* spp.). In those four genera, the axial canals are arranged in long tangential series.

(iii) *Cotylelobium* can be readily distinguished from Keruing (*Dipterocarpus* spp.) and Mersawa (*Anisoptera* spp.) by its finer texture and higher density.

(iv) The numerous pores and presence of silica in *Cotylelobium* readily distinguish the timber from Penyau (*Upuna borneensis*).

Dipterocarpus

FIELD CHARACTERISTICS

All thirty-two species of *Dipterocarpus*, which occur in Sarawak are known as Keruing. It is one of the most characteristic trees of the lowland dipterocarp forests, extending into the hills to an altitude of about 3,000 feet, although one or two species are to be found in the peat swamps. *Dipterocarpus* usually occurs on yellow sandy soils, narrow shale ridges, clay hillsides, alluvium or peat. Some species are widespread but others tend to be localised. *Dipterocarpus* trees are large, with a maximum height exceeding 200 feet and a girth of over 20 feet; but more commonly they occur as trees of 150–180 feet in height with a girth range of 12–16 feet, according to species. The trees have tall, straight, cylindrical boles, with thick, rounded, buttresses. Bark surface is pale or dark grey to orange-brown, sometimes pink-brown, flaked or shaggy, with prominent warty lenticels. Dammar does not occur on unbroken bark surfaces but appears rapidly as clear sticky drops on freshly cut surfaces.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, rarely with radial pairs, oblique in arrangement, generally oval in outline, usually moderately few, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete sheaths to the vessels; diffuse; forming short tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present) with 1–3 marginal rows of square or upright cells; sheath cells sometimes present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Vasicentric tracheids observed in most species.

Fibres with moderately conspicuous bordered pits, walls thick.

Intercellular Canals. Axial canals arranged singly and in short tangential series of 2–7, diameter considerably less than that of the vessels; canals blocked with whitish resinous contents.

Crystals. Wanting.

Silica. Abundant in ray cells of all species except *D. borneensis* in which it is sparse.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood grey-brown or yellow-brown and distinct from heartwood; 1½–3 inches wide.

Heartwood pink-brown, purple-brown or red-brown, with a purple tinge, darkening on exposure.

The timber of *Dipterocarpus* is hard but varies in density, ranging between 38–62 lb. per cu. ft. air-dry, according to species. An average air-dry density of 45 lb. per cu. ft. may serve as an useful criterion to separate the timber into two classes, the medium weight and the heavy weight.

Grain straight or shallowly interlocked; texture moderately coarse to coarse and even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals, arranged singly and in short tangential series of 2–7, can be used to distinguish the timber of *Dipterocarpus* from that of non-dipterocarps and from that of most other dipterocarps.

(ii) Two features can be used to distinguish the timber of *Dipterocarpus* from that of *Anisoptera* (Mersawa): (*a*) the timber of *Dipterocarpus* has a pink-brown cast, that of *Anisoptera* a yellowish colour; (*b*) in *Dipterocarpus* the pores are arranged in an oblique pattern but, in *Anisoptera*, are evenly distributed with no apparent pattern.

(iii) Confusion with Resak (*Cotylelobium* spp. and *Vatica* spp.) or Penyau (*Upuna borneensis*) is unlikely because of the much coarser texture of *Dipterocarpus*.

Dryobalanops

FIELD CHARACTERISTICS

Six species of *Dryobalanops* (Kapur) are known to occur in Sarawak. They are common trees of the lowland and hill forests but one species, *D. rappa* is to be found in the peat swamps. They usually grow on shallow yellow sandy soils derived from ferrugineous sandstone, white sand terraces, clay soils derived from basalt, sandy loam soils or peat. All species develop into large or very large trees, often growing to a height of over 200 feet and a maximum girth of 20 feet. The trees have tall, straight and cylindrical boles, with long, concave, rather thick, plank buttresses. Bark surface is of variable colour according to the species, evenly or persistently flaked, with distinct lenticels on fresh surfaces. Dammar is not exuded from cut surfaces, nor does it occur on the bole. Some species (*D. aromatica, D. lanceolata*) produce crystalline camphor in fissures within the heartwood.

WOOD ANATOMY

Pores/Vessels. Almost exclusively solitary, with a few radial multiples of 2–3, oblique in arrangement, generally round to oval in shape, moderately numerous, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, as incomplete borders to the vessels, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–6 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, type I occasionally present in *D. beccarii*) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present. Rays tend to be storied or arranged in echelon (except *D. rappa*).

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls thick. Cells intermediate between vasicentric tracheids and fibre-tracheids often occur in the immediate proximity of the vessels.

Intercellular Canals. Axial canals in continuous tangential rows, diameter considerably less than that of the vessels; canals filled with whitish resinous contents.

Crystals. Only in *D. fusca* and *D. rappa* in idioblasts and parenchyma, rhomboidal in shape.

Silica. Abundant in ray cells of all species except *D. rappa* in which silica is sparse.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood yellow-brown and clearly differentiated from heartwood; 1–2½ inches wide.

Heartwood red-brown or pink-brown, darkening on exposure.

The timber is hard and heavy; air-dry density of the hill species (Kapur Bukit) averaging about 50 lb. per cu. ft. (range: 45–55 lb. per cu. ft.) and the swamp species (Kapur paya) being a little lighter, averaging only 45 lb. per cu. ft. (range: 42–48 lb. per cu. ft.).

Grain straight or shallowly interlocked; texture moderately coarse and even; freshly cut wood has a pronounced camphor-like odour but the smell tends to disappear on seasoning.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals arranged in long tangential series provides a reliable diagnostic feature for distinguishing this timber from non-dipterocarp timbers and from Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Penyau (*Upuna borneensis*) and Resak (*Cotylelobium* spp. and *Vatica* spp.). In those four dipterocarps, the axial canals are diffuse or in short tangential series.

(ii) The timber can be distinguished from all Merantis and Selangan Batu (*Shorea* spp.), Selangan and Giam (*Hopea* spp.) and White Seraya (*Parashorea* spp.) by its almost exclusively solitary pores and camphor-like odour when freshly cut.

Hopea

FIELD CHARACTERISTICS

In this genus a considerable amount of taxonomic work has still to be done but, already, about forty species of *Hopea* are recognised in Sarawak where they form a very variable group in both the lowland and the hill forests. Within the genus two groupings of species are commonly recognised: (i) Giam — a very hard, heavy, durable timber closely related to the Selangan Batu group (*Shorea* spp.); common species *H. nutans, H. pentanervia*, and *H. semicuneata* (ii) Selangan (Merawan in West Malaysia) — timber less hard and heavy than Giam; common species *H. beccariana, H. nervosa* and *H. sangal*. Some *Hopea* species are locally abundant, usually growing on alluviums, calcareous shales, clay soils or yellow sandy soils on ridges and hillsides, but a few are to be found on damp hillsides, near rivers, shallow peat or swampy soils overlying white sand. The trees are usually small, occasionally medium-sized, maximum height 90–120 feet, with a girth of 6–10 feet. Boles are usually tapering, frequently branching low. Buttresses are usually thin, sometimes thick; stilt roots sometimes present. Bark surface is at first smooth, chocolate- and grey-mottled, hoop-marked, becoming cracked and flaked or fissured. The Giam trees usually have a pale yellowish, the others a clear white dammar, sometimes in stalactitic form.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, occasionally in small clusters, round in shape, moderately numerous to numerous, evenly distributed, moderately small to medium-sized (size 3–4); intervascular pitting alternate, moderately fine, pits vestured; perforation plates simple; tyloses abundant.

Parenchyma. Paratracheal, usually as incomplete borders to the vessels, aliform, occasionally confluent; apotracheal, in irregularly spaced, narrow, terminal bands or in short, uniseriate lines between rays; forming continuous tangential layers enclosing the axial intercellular canals.

Rays. Uniseriate (fine) and 2–5 cells wide (medium-sized), occasionally up to 7 cells wide; low, less than 2 mm. in height; heterogeneous (Kribs's types II and III, sometimes type I) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Vasicentric tracheids present in all species, the cells irregular in shape and with conspicuous bordered pits. Fibres with indistinctly bordered pits, walls moderately thin in the Selangan group but very thick in Giam.

Intercellular Canals. Only axial canals present, in continuous tangential rows, variable in size, usually equal to or smaller than that of the vessels but sometimes larger; canals usually blocked with chalky deposits.

Crystals. Always present, rhomboidal in shape, in ray cells or parenchyma or both, occasionally chambered or sub-divided, sometimes in idioblasts.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood lighter in colour than the heartwood, about 1–2 inches wide, often with a greyish tinge, poorly differentiated from the heartwood.

Heartwood yellow or light yellow-brown when freshly cut, darkening to red-brown on exposure.

Timber weighing over 60 lb. per cu. ft. air-dry, i.e. Giam, is hard and durable; the lighter wood (40–60 lb. per cu. ft. air-dry), i.e. Selangan, moderately hard, less durable.

Grain, usually shallowly interlocked, sometimes wavy or spiral; texture fine or moderately fine, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals in continuous tangential series separates the timber from non-dipterocarps.

(ii) The same feature serves to distinguish *Hopea* from Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and

Penyau (*Upuna borneensis*), all of which have axial canals in a diffuse arrangement or in short tangential series.

(iii) Giam can be distinguished from Selangan Batu (*Shorea* spp.) by its finer texture.

(iv) Selangan resembles Yellow Meranti (*Shorea* spp.), but can be distinguished from it by the absence of radial canals in its rays and the even distribution of its pores. In Yellow Meranti, pores have a radial arrangement.

Parashorea

FIELD CHARACTERISTICS

Four species of *Parashorea* (White Seraya) are known to occur in Sarawak, usually growing on damp sticky clay on hillsides near rivers and streams or on well drained clay spurs and ridges. The genus has not been recorded from west of the Batang Lupar. All species grow to large trees, maximum height 150–180 feet, with a girth of about 12 feet. The trees have tall, straight and cylindrical boles, with large, rounded and slightly concave buttresses. Bark surface is distinctly mauve-grey to purplish, with narrow, shallow fissures, broad, smooth or flaking flat ridges, and numerous conspicuous large pale corky lenticels. Dammar is creamy to yellowish, exuding from rows of resin canals on cut surfaces.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, generally round to oval, moderately few, medium-sized to very large (size 4–6), mostly moderately large (size 5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, vasicentric, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers surrounding the axial intercellular canals.

Rays. Uniseriate (fine) and 2–7 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's type III, occasionally type II), commonly with 1 marginal row of square or upright cells; sheath cells sometimes present.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Vasicentric tracheids always present, the cells irregular in shape and with conspicuous bordered pits. Fibres with simple pits, walls thin in *P. macrophylla* and *P. malaanonan* but thick in *P. parvifolia* and *P. smythiesii.*

Intercellular Canals

(i) Axial canals in continuous tangential rows, often rather widely spaced, diameter considerably less than that of the vessels; canals usually filled with chalky or yellow-white contents.

(ii) Radial canals absent from all the Sarawak specimens but observed in *P. smythiesii* of Sabah origin.

Crystals. Always present, usually rhomboidal, in parenchyma, chambered, usually in long strands; in ray cells, sometimes more than one per cell.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood paler in colour than the heartwood, usually 2–3 inches wide, commonly stained with fungus; fairly distinct from the heartwood.

Heartwood pinkish or straw-coloured, darkening to light brown on exposure, with a distinctive brownish tinge.

The timber of *Parashorea* may be divided into two classes, based on its density: (i) *P. malaanonan* and *P. macrophylla* are of medium weight, averaging between 35 and 42 lb. per cu. ft. air-dry; (ii) *P. parvifolia* and *P. smythiesii* are heavy timbers, averaging between 48 and 52 lb. per cu. ft. air-dry. Both groups of timber are moderately hard.

Grain interlocked; texture rather coarse, even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals distinguishes the timber of *Parashorea* from non-dipterocarps.

(ii) The presence of axial canals in long tangential series serves to separate the timber of *Parashorea* from *Keruing* (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Resak (*Cotylelobium* spp. and *Vatica* spp.) and Penyau (*Upuna borneensis*).

(iii) In *Parashorea,* the pores are often in radial multiples of 2–4, an arrangement quite different from Kapur (*Dryobalanops* spp.) in which the pores are almost exclusively solitary.

(iv) The timber is unlikely to be confused with Selangan and Giam (*Hopea* spp.) since those timbers are of a fine texture.

(v) Confusion with *Shorea* — see under *Shorea.*

Shorea

This is the largest genus within the family Dipterocarpaceae with at least one hundred and twenty species known to occur in Sarawak. All are trees capable of yielding commercial timbers but some are of no commercial importance because of inaccessibility or scarcity. Symington (1934) pointed out that, in West Malaysia, groups of species within the genus could usually be recognised in the field from bark and slash characters combined with the gross timber morphology. This grouping of species corresponds closely with local practice in the Sarawak timber industry.

In Sarawak, the accepted grouping of species within the genus generally corresponds to anatomical features or timber properties and the differences between the groups are both constant and distinct. The four groupings recognised in Sarawak are: —

I THE RED MERANTI GROUP
  Sub-group 1. Light Red Meranti
  Sub-group 2. Dark Red Meranti
  Sub-group 3. Red Selangan (Red Balau)
II THE SELANGAN BATU (BALAU) GROUP
III THE WHITE MERANTI GROUP
IV THE YELLOW MERANTI GROUP

FIELD CHARACTERISTICS

The Red Meranti Group

Botanists recognise sixty-two species of *Shorea* in the Red Meranti group which is the most important group of timber trees in Sarawak. Red Merantis are to be found in all types of forest, except the mangroves, from sea-level to about 3,000 feet altitude. All species develop into medium- to large-sized trees with, according to species, a maximum height of 120 feet to over 200 feet. Trees with a girth of 24 feet are not unknown, although 12–14 feet is more common. The trees usually have clean, straight boles, with large, thick, rounded buttresses. The bark surface is very variable, but the inner bark is red, pink-brown, orange-brown, rarely coffee coloured, and usually fibrous and relatively soft. Dammar exudations are commonly present, of variable colour when fresh but oxidising from cream to yellow on exposure.

The Selangan Batu (Balau) Group

Twenty-five species of Selangan Batu (in West Malaysia under the name of Balau) are known to occur in Sarawak. Some are abundant locally, usually on well-drained sandy soils. They are common in the lowland forests but do not occur in the swamp and mangrove forests. The trees are usually small to medium-sized, maximum height 100–150 feet according to species, but giants of about 220 feet with a girth exceeding 20 feet are occasionally found. Boles are variable. Buttresses are prominent, narrow and sharp. Bark surface is longitudinally cracked, thinly or shaggily flaked; dull grey-brown, yellow-brown, tawny or chocolate and indistinctly lenticellate. Dammar is frequently present as pale yellowish to brown smears on the bole.

The White Meranti Group

Of the eight species of White Meranti known to occur in Sarawak, seven are fairly common in the lowland forests and one in the heath forests; they are not found in the peat swamp forests. The trees usually grow on well-drained or sandy clay soils on ridges and hillsides, on relatively fertile soils derived from igneous rocks, or on shallow podsolic sandy soils. Most species develop into medium- to large-sized trees, maximum height 150–165 feet, with a girth of about 12–15 feet. The trees usually have tall, straight, cylindrical boles except *S. ochracea* which is frequently twisted or crooked. Buttresses are prominent, thick and rounded. Bark surface is pale or dark, irregularly fissured. Dammar exudation is pale yellow.

The Yellow Meranti Group

Twenty-five species of this group are found in Sarawak, occurring from lowland to hill forests in a wide variety of habitats. Yellow Meranti is usually found on well-drained soils or on soils derived from calcareous shales or igneous rocks, but never on deep peats. With some exceptions, they are large trees reaching a maximum height of over 200 feet with a maximum girth in excess of 25 feet. Boles are variable. Buttresses are small or prominent, of medium thickness, narrowly rounded. Bark surface is at first smooth, chocolate and grey dappled, becoming pale or dark tawny-brown, rarely chocolate-brown, irregularly and longitudinally cracked or flaked, closely and deeply fissured. Dammar is characteristically dull, dark grey-brown to black, readily exuding on cut surfaces; stalactitic exudations are usually abundant on the bole.

WOOD ANATOMY

Pores/Vessels. Solitary and sometimes in radial multiples of 2–4, in characteristic groups of 3–5 in the White Meranti; generally round to oval in shape, moderately few to moderately numerous, usually moderately small to medium-sized (size 3–4) in Light Red Meranti, Selangan Batu and Yellow Meranti, but in Dark Red Meranti, Red Selangan and White Meranti, medium-sized to moderately large (size 4–5); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses usually abundant.

Parenchyma. Paratracheal, vasicentric, aliform, occasionally confluent; diffuse and diffuse-in-aggregates; forming continuous tangential layers around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–8 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round, with large aperture.

Tracheids and Fibres. Vasicentric tracheids always present, the cells irregular in shape and with conspicuous bordered pits. Fibres with simple pits, walls thin in Light Red Meranti, White Meranti and Yellow Meranti; thick in Dark Red Meranti, Red Selangan and some species of Yellow Meranti, but in Selangan Batu, very thick.

Intercellular Canals

(i) Axial canals in continuous tangential rows, diameter considerably less than that of the vessels except in Dark Red Meranti where the canals are often as large as the vessels; canals usually blocked with chalky or yellowish deposits.

(ii) Radial canals present in all species of Yellow Meranti and the following species of Red Meranti:—*Shorea leprosula, S. ovata, S. parvistipulata, S. scabrida* and *S. teysmanniana.*

Crystals. Occasionally present in all groups except White Meranti; in idioblasts, usually rhomboidal in shape, in parenchyma and ray cells.

Silica. Present in White Meranti in ray cells, but totally absent from other groups.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Red Meranti Group

Sapwood distinct, light yellow-brown or light grey-brown; about 1–2 inches wide.

Heartwood red or red-brown in Light Red Meranti; in Red Selangan and Dark Red Meranti, deep purple-red or dark red-brown, with prominent white or yellow-white lines of resin canals on all surfaces.

The timber of Light Red Meranti is soft to moderately hard, light to medium in weight averaging about 35 lb. per cu. ft. (range: 25–45 lb. per cu. ft.) air-dry; Dark Red Meranti and Red Selangan are harder and heavier, with the average air-dry densities of 45 lb. per cu. ft. (range: 42–55 lb. per cu. ft.) and 55 lb. per cu. ft. (range: 48–60 lb. per cu. ft.) respectively.

Grain straight or shallowly interlocked; texture even, rather coarse in Dark Red Meranti but finer in Red Selangan and Light Red Meranti.

Selangan Batu (Balau) Group

Sapwood fairly distinct from, and lighter in colour than the heartwood; about 1–2 inches wide.

Heartwood yellow-brown, grey-brown or brown, on exposure darkening to dark brown or dark red-brown.

The timber is very hard and heavy, averaging about 63 lb. per cu. ft. (range: 58–70 lb. per cu. ft.) air-dry.

Grain usually interlocked and wavy; texture moderately fine and even.

White Meranti Group

Sapwood lighter in colour than the heartwood and fairly distinct from it; about 2 inches wide.

Heartwood almost white when freshly sawn, later darkening to yellow-brown or buff-coloured.

The timber is moderately hard and medium-heavy, with an average air-dry density of 41 lb. per cu. ft. (range: 36–47 lb. per cu. ft.).

Grain usually shallowly interlocked; texture moderately coarse and even.

Yellow Meranti Group

Sapwood lighter in colour than the heartwood, with a greenish tinge and fairly distinct from the heartwood; 1–2½ inches wide.

Heartwood light yellow-brown, darkening on exposure.

The timber is moderately hard and medium-heavy, average weight 44 lb. per cu. ft. (range: 36–56 lb. per cu. ft.) air-dry.

Grain usually shallowly interlocked and sometimes wavy; texture moderately coarse and even.

Key to the timber groups in Shorea

1. (a) Silica present in the ray cells*; pores in characteristic groups of 3–5; wood white .... WHITE MERANTI
   (b) Silica absent; wood not as above 2
2. (a) Wood over 60 lb. per cu. ft. air-dry; wood very hard .... SELANGAN BATU
   (b) Wood below 60 lb. per cu. ft. air-dry; wood never hard 3
3. (a) Wood yellow; ray tissue bright yellow; radial intercellular canals always present* .... YELLOW MERANTI
   (b) Wood red or red-brown; ray tissue not bright yellow; radial intercellular canals present only in a few species of Red Meranti 4
4. (a) Wood parenchyma prominent, tending to short lines between rays; axial intercellular canals prominent on all surfaces 5
   (b) Wood parenchyma not prominent; axial intercellular canals distinct on all surfaces but not prominent .... LIGHT RED MERANTI
5. (a) End-cut glistening or waxy .... RED SELANGAN
   (b) End-cut dull .... DARK RED MERANTI

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*Microscopic feature.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals arranged in long tangential series precludes the possibility of confusing the timber of *Shorea* with non-dipterocarp timbers and with Keruing (*Dipterocarpus* spp.), Mersawa (*Anisoptera* spp.), Penyau (*Upuna borneensis*) and Resak (*Cotylelobium* spp. and *Vatica* spp.). In those four Dipterocarps, the axial canals are diffuse or in short tangential series.

(ii) The timber of *Shorea*, with pores in radial multiples of 2–4 is readily distinguished from that of Kapur (*Dryobalanops* spp.) in which the pores are almost exclusively solitary. Further, unlike *Shorea* which is odourless, Kapur has a camphor-like odour when freshly cut.

(iii) Superficially the wood of *Hopea* species (Selangan and Giam) may resemble that of Yellow Meranti and Selangan Batu (*Shorea* spp.), especially in colour. The absence of any radial arrangement in the vessels and of radial canals in the rays can be used to separate Selangan from Yellow Meranti. Although both Giam and Selangan Batu are very heavy timbers, Giam may be recognised by its finer texture.

(iv) When White Seraya (*Parashorea* spp.) is confused with Red or White Meranti, it may sometimes be distinguished by its coarser texture and distinctive brownish tinge. In doubtful cases, a microscopic examination of White Seraya will reveal distinctive, chambered, crystalliferous parenchyma in long strands; these strands do not occur in Red or White Meranti although silica is to be found in the ray cells of White Meranti and Red Meranti may have some crystalliferous parenchyma.

Upuna

FIELD CHARACTERISTICS

Upuna is a monotypic genus with *U. borneensis* as the only species. *U. borneensis*, locally known as Penyau, is scattered through the lowland forests, on well drained ridges and deep yellow sandy clay soils. In Sarawak, it is widely distributed but never abundant. This species develops into a large tree, attaining a height of 160 feet and a girth of 18 feet. The tree has a tall, straight, cylindrical and well-shaped bole, with buttresses varying from small and stout to very large. Bark surface is dark purple-brown to chocolate, irregularly scaly. Dammar is pale yellow.

WOOD ANATOMY

Pores/Vessels. Exclusively solitary, generally round to oval in outline, moderately few, moderately small to medium-sized (size 3–4); intervascular pitting alternate, moderately coarse, pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete borders to the vessels; apotracheal, diffuse and diffuse-in-aggregates; around the axial intercellular canals, occasionally forming more or less continuous tangential layers.

Rays. Uniseriate (fine) and 2–7 cells wide (medium-sized); low, less than 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and in pairs throughout the fibres, sometimes in more or less continuous tangential rows, diameter usually smaller than that of the vessels.

Crystals. Wanting.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood pale to light brown and distinct from heartwood; about ½–1 inch wide.

Heartwood brown, later darkening to dark brown.

The timber is very hard and very heavy, with an average air-dry density of 65 lb. per cu. ft. (range: 60–70 lb. per cu. ft.).

Grain shallowly interlocked and wavy; texture fine and even.

DISTINGUISHING FEATURES

(i) The presence of axial intercellular canals, arranged singly and sometimes in more or less continuous tangential series distinguishes the timber from non-dipterocarps and from most other dipterocarps.

(ii) The timber of *Upuna borneensis* resembles Resak (*Cotylelobium* spp. and *Vatica* spp.), but the comparatively fewer pores in *Upuna borneensis* preclude the possibility of confusing it with Resak. In Resak, the pores are numerous to very numerous. *Upuna borneensis* which has no silica is readily distinguished from *Cotylelobium* spp.

(iii) The timber can be separated from Mersawa (*Anisoptera* spp.) and Keruing (*Dipterocarpus* spp.) by its higher density and much finer texture.

Vatica

FIELD CHARACTERISTICS

A widely distributed genus consisting of about twenty-eight species in Sarawak. A few species occur in the peat swamps, and the remainder in the lowland and hill forests. All species of *Vatica*, as well as *Cotylelobium*, are commonly known as Resak. *Vatica* is usually found on clay soils on hillsides and ridges, white sandy soils on terraces, rentzinas on limestone hills, peat soils, clay alluviums or on shale, basalt and dacite slopes at higher altitudes. The trees are mostly rather small, maximum height between 80 and 100 feet, with a girth of about 3–5 feet. Boles are frequently sinuate. Buttresses are thick, rounded, concave and usually small. Bark surface is usually grey-mottled, smooth, hoop-marked, becoming patchily flaked and occasionally scroll-marked in large trees. Dammar is rare on bark surfaces but clear when it exudes from cut surfaces.

WOOD ANATOMY

Pores/Vessels. Mostly solitary with occasional radial, tangential and oblique pairs, evenly distributed, generally round, numerous to very numerous, moderately small to medium-sized (size 3–4); intervascular pitting alternate, rare, tending to opposite or scalariform in *V. granulata, V. havilandii, V. mangachapoi, V. sarawakensis* and *V. umbonata,* pits vestured; perforation plates simple; tyloses present.

Parenchyma. Paratracheal, as incomplete borders to the vessels, sometimes abaxially aliform, confluent; diffuse and diffuse-in-aggregates; around the axial intercellular canals.

Rays. Uniseriate (fine) and 2–10 cells wide (medium-sized); usually low, but sometimes up to 2 mm. in height; heterogeneous (Kribs's types II and III) with 1–3 marginal rows of square or upright cells; sheath cells occasionally present.

Vessel-ray Pitting. Simple, round to elongated, with large aperture.

Tracheids and Fibres. Fibres with moderately conspicuous bordered pits, walls very thick.

Intercellular Canals. Axial canals scattered singly and sometimes in pairs throughout the fibres, diameter less than that of the larger vessels but as large as some of the smaller vessels; Canals usually packed with chalky deposits.

Crystals. Sometimes present, usually rhomboidal in shape, in chambered parenchyma or ray cells or both, rarely more than one per cell.

Silica. Wanting.

Growth Rings. Absent.

PHYSICAL PROPERTIES

Sapwood pale brown or yellow-brown, usually 1–3 inches wide, sharply differentiated from the heartwood when green, but less so when dry.

Heartwood red-brown, with a pink tinge, darkening to deep or dark reddish brown.

The timber of *Vatica* varies in hardness, density and durability. The local people often distinguish *Resak Batu,* the harder, heavier and more durable species, from *Resak Bunga* which is lighter and of lower durability. An average air-dry density of 60 lb. per cu. ft. may serve as an useful criterion to separate the two classes. However, it should be noted that the timber of a given species will be either *Resak Batu* or *Resak Bunga* according to density of individual trees, although *V. mangachapoi* and *Cotylelobium* usually produce timber of only the Resak Batu Class.

DISTINGUISHING FEATURES

(i) The timber of *Vatica* resembles that of Penyau (*Upuna borneensis*) from which it can usually be distinguished by its more numerous and smaller pores. In Upuna the pores are exclusively solitary; with *Vatica* this is not so.

(ii) Separation from other timbers — see under *Cotylelobium.*

TABLE 1—SUMMARY OF ANATOMICAL CHARACTERISTICS OF 9 GENERA OF THE DIPTEROCARPACEAE OCCURRING IN SARAWAK

		Vessels						Parenchyma					Rays								Intercellular Canals					Crystals					
				Inter-vascular Pitting				Paratracheal		Apotracheal				Heterogeneous, kribs's Types							Axial										
																							Diameter								
Genus And Group	No. of Species Examined	Percentage Solitary	Tangential Diameter-micron	Arrangement, Alternate	Pits Vestured	Perforation Plates Simple	Tyloses	Paratracheal To Vasicentric	Aliform To Confluent	Diffuse	Tending To Short Lines	Narrow Bands	Width – No. of Cells	I	II	III	Sheath Cells	Vessel-ray Pitting Simple, Round To Elongated	Vasicentric Tracheids	Fibres With Moderately Conspicuous Bordered Pits	In Long Tang'l. Series	Diffuse Or In Short Series	Less Than Vessels	Equal To, Greater Than Vessels	Radial	In Idioblasts	In Parenchyma	In Ray Cells	Chambered	More Than One Per Cells	Silica Present In The Ray Cells
Anisoptera ..	4	88–96	192–226	+	+	+	+	+	+	+	+	–	1–7	–	+	+	–	+	–(1)	+	(+)	+	+	–	–	–	–	–	–	–	+
Cotylelobium ..	3	95–98	124–137	+	+	+	+	+	+	+	(+)	–	1–8	(–)	+	+	(+)	+	–	+	–	+	+	+	–	–	–	–	–	–	+
Dipterocarpus ..	30	87–97	187–264	+	+	+	+	+	–	+	–	–	1–8	(+)	+	+	(+)	+	(+)	+	–	+	+	–	–	–	–	–	–	–	+(2)
Dryobalanops ..	6	89–95	180–232	+	+	+	+	+	+	+	–	–	1–6	(–)	+	+	(+)	+	–(1)	+	+	–	+	–	–	(–)	(–)	–	–	–	+(2)
Hopea ..	28	52–84	102–172	+	+	+	+	+	+	+	+	+	1–5	(+)	+	+	(+)	+	+	–	+	–	+	+	–	(+)	+	+	(+)	–	–
Parashorea ..	4	78–86	239–307	+	+	+	+	+	+	+	–	–	1–7	–	(+)	+	(+)	+	+	–	+	–	+	–	–	–	+	+	+	(+)	–
Shorea —Red Meranti	60	50–89	179–275	+	+	+	+	+	+	+	(–)	–	1–7	–	+	+	(+)	+	+	–	+	–	+	(–)	(–)	(+)	(+)	(+)	(–)	–	–
—Selangan Batu	24	49–82	134–217	+	+	+	+	+	+	+	–	–	1–7	–	+	+	(–)	+	+	–	+	–	+	–	–	(+)	(+)	–	(+)	–	–
—White Meranti	7	53–71	153–254	+	+	+	+	+	+	+	–	–	1–6	–	+	+	–	+	+	–	+	–	+	–	–	–	–	–	–	–	+
—Yellow Meranti	22	46–66	146–233	+	+	+	+	+	+	+	–	–	1–8	–	+	+	(+)	+	+	–	+	–	+	–	+	–	(+)	(+)	(–)	(–)	–
Upuna ..	1	98	162–197	+	+	+	+	+	–	+	–	–	1–7	–	+	+	+	+	–	+	(+)	+	+	–	–	–	–	–	–	–	–
Vatica ..	21	47–90	88–147	+	+	+	+	+	+	+	–	–	1–10	–	+	+	(+)	+	–	+	–	+	+	+	–	–	(+)	(+)	(+)	(–)	–

+ = Present.
– = Absent.
(+) Usually present, majority of species conforming.
(–) Usually absent, present in some species.
(1) & (2) See text under generic description.

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
Anisoptera (4 spp.)	Mersawa			
—grossivenia V. Sl.	Mersawa kunyit	6	49.2	44.4–56.2
—laevis Ridl.	Mersawa durian	4	44.8	40.5–50.5
—marginata Korth.	Mersawa paya	5	45.3	41.5–49.7
—reticulata Ashton	—	1	48.4	—
Cotylelobium (3 spp.)	Resak			
—burckii Heim.	Resak durian	5	66.6	62.0–71.1
—malayanum V. Sl.	Resak bukit	3	67.3	63.7–72.4
—melanoxylon (Hook f.) Pierre	Resak hitam	5	58.3	55.9–61.0
Dipterocarpus (30 spp.)	Keruing			
—acutangulus Vesque	Keruing beludu	6	51.0	49.3–56.7
—applanatus V. Sl.	Keruing arong	6	48.3	43.1–51.8
—apterus Foxw.	Keruing latek	5	39.3	38.2–39.9
—borneensis V. Sl.	Keruing sindor	5	50.5	47.4–54.7
—caudiferus Merr.	Keruing puteh	6	44.1	41.8–48.7
—confertus V. Sl.	Keruing kobis	5	53.3	48.2–58.0
—conformis V. Sl.	Keruing beludu kuning	3	49.0	44.8–54.0
—coriaceus V. Sl.	Keruing paya	5	42.8	40.7–45.1
—costulatus V. Sl.	Keruing kipas	2	50.5	46.9–54.0
—crinitus Dyer	Keruing mempelas	6	59.2	54.9–61.8
—cuspidatus Ashton	Keruing runching	4	50.1	48.0–53.7
—eurynchus Miq.	Keruing baran	2	46.1	44.6–47.6
—exalatus V. Sl.	Keruing kuntum puteh	5	41.8	38.7–45.0
—fagineus Vesque	Keruing pipit	1	50.2	—
—geniculatus Vesque	Keruing kerubong	4	47.9	45.4–50.9
—globosus Vesque	Keruing buah bulat	5	52.0	47.8–55.8
—gracilis Bl.	Keruing kesat	5	48.1	43.4–54.0
—humeratus V. Sl.	Keruing latek bukit	2	48.7	45.5–51.8
—lowii Hook f.	Keruing sol	3	49.3	44.1–55.2
—mundus V. Sl.	—	2	49.7	49.5–49.9
—nudus V. Sl.	Keruing lichin	5	53.9	50.5–56.7
—oblongifolius Bl.	Keruing neram	5	47.8	40.6–51.2
—pachyphyllus Meijer	Keruing sol padi	5	52.2	47.4–55.2
—palembanicus V. Sl.	Keruing ternek	5	45.8	42.2–48.8
—penangianus Foxw.	Keruing gasing	5	55.8	53.3–58.0
—rigidus Ridl.	Keruing utap	5	49.9	43.7–53.7
—sarawakensis V. Sl.	Keruing layang	5	49.4	45.1–55.2
—stellatus Vesque	Keruing daun nipis	5	56.1	49.3–60.0
—tempehes V. Sl.	Keruing tepayan	5	41.0	37.7–45.9
—verrucosus V. Sl.	Keruing merah	5	53.6	52.4–56.0
Dryobalanops (6 spp.)	Kapur			
—aromatica Gaertn. f.	Kapur peringgi	5	55.0	53.5–56.2
—beccarii Dyer	Kapur bukit	5	49.0	46.9–50.0
—fusca V. Sl.	Kapur empedu	5	54.0	52.7–55.5
—lanceolata Burck	Kapur paji	5	45.0	42.1–48.3
—oblongifolia Dyer	Kapur kelansau	5	54.0	47.4—59.9
—rappa Becc.	Kapur paya	5	45.0	40.1–48.4
Hopea (28 spp.)	Giam, Selangan(merawan), etc.			
—aequalis Ashton	—	1	54.3	—
—altocollina Ashton	Luis gunong	2	49.0	46.4–51.6
—andersoni Ashton	Luis somit	5	59.1	56.4–62.4
—argentea Meijer	Luis timbul	2	58.6	56.8–60.4
—beccariana Burck	Selangan penak	4	57.7	56.2–59.3
—bracteata Burck	Merawan padi	5	42.3	39.7–45.8

Table 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
—centipeda Ashton	—	4	47.2	40.5–50.9
—cernua T. et B.	—	3	58.0	55.6–62.3
—dasyrrhachis V. Sl.	—	1	70.5	—
—dryobalanoides Miq.	Mata kuching hitam	4	48.6	44.9–53.3
—dyeri Heim	Merawan palit	4	52.8	50.9–57.2
—enicosanthoides Ashton	Luis selukai	1	56.6	—
—fluvialis Ashton	Merawan Ayer	2	69.1	68.6–69.6
—griffithii Kurze	Luis jantan	1	67.2	—
—latifolia Sym.	Merawan daun bulat	2	58.7	54.0–63.4
—megacarpa Ashton	—	1	60.5	—
—mesuoides Ashton	—	1	59.3	—
—micrantha Hook f.	Merawan kerangas	2	47.4	46.6–48.1
—nervosa King	Merawan jangkang	3	48.8	43.3–54.9
—nutans Ridl.	Giam	1	63.0	—
—pachycarpa (Heim.) Sym.	Merkoyong	5	52.2	47.8–56.1
—pedicellata (Brandis) Sym.	Mata kuching bukit	1	50.5	—
—pentanervia Sym.	Mang	7	72.9	68.5–76.1
—pterygota Ashton	—	1	62.7	—
—sangal Korth.	Gagil	2	46.9	43.3–50.5
—semicuneata Sym.	Sama rupa chengal	2	57.3	55.3–59.3
—tenuinervula Ashton	—	1	63.7	—
—treubii Heim	Merawan daun tebal	2	58.6	58.5–58.7
Parashorea (4 spp.)	White Seraya			
—macrophylla Wyatt-Smith ex Ashton	Peran	7	42.3	38.4–45.4
—malaanonan (Blanco) Merr.	Urat mata	4	35.8	32.0–42.4
—parvifolia Wyatt-Smith ex Ashton	Urat mata bukit	5	48.8	46.4–54.5
—smythiesii Wyatt-Smith ex Ashton	Meruyun	6	51.9	47.4–54.0
Shorea (56 spp.)	Red meranti group			
—acuta Ashton	Meranti kawang tikus	1	34.3	—
—albida Sym.	Alan bunga	5	28.3	23.4–32.8
	Alan	7	51.0	41.8–57.0
—almon Foxw.	—	5	34.4	31.3–38.1
—amplexicaulis Ashton	Meranti kawang pinang lichin	5	35.9	30.8–37.8
—andulensis Ashton	Meranti daun puteh	1	43.1	—
—argentifolia Sym.	Meranti binatoh	6	42.5	38.2–45.6
—beccariana Burck	Meranti langgai	6	40.1	36.4–43.1
—bullata Ashton	Meranti melechur	2	49.9	47.4–52.3
—carapae Ashton	Abang uloh	1	42.2	—
—coriacea Burck	Meranti tangkai panjang	5	50.6	46.7–54.3
—cristata Brandis	Meranti kawang pinang	3	38.8	38.1–40.3
—curtisii Dyer	Seraya	5	50.1	48.2–52.1
—dasyphylla Foxw.	Meranti batu	3	32.8	29.8–36.8
—elliptica Burck	Meranti lang	3	43.6	40.1–48.5
—fallax Meijer	Engkabang layar	5	39.4	35.3–43.2
—ferruginea Dyer ex Brandis	Meranti menalit	6	42.0	34.5–47.4
—flaviflora Wood ex Ashton	Selangan merah bukit	5	47.0	43.7–51.1
—flemmichii Sym.	Meranti raya	1	48.0	—
—inaequilateralis Sym.	Semayor	5	56.4	53.1–60.6
—kunstleri King	Damar laut merah	3	58.3	56.0–60.7
—leprosula Miq.	Meranti tembaga	5	37.9	36.2–40.4
—leptoclados Sym.	Meranti Majau	3	34.0	32.7–35.6
—macrantha Brandis	Engkabang bungkus	4	51.5	46.1–55.5

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
—macrophylla (De Vr.) Ashton	Engkabang jantong	4	29.9	24.7—33.3
—macroptera Dyer	Meranti melantai	5	41.2	37.7—44.4
—mecistopteryx Ridl.	Engkabang larai	5	35.4	31.8—38.6
—monticola Ashton	Meranti gunong	5	49.0	45.4—54.1
—myrionerva Wood ex Ashton	Meranti sepit undang	2	41.1	40.1—42.1
—ovalis (Korth) Bl.	Meranti kepong	3	34.9	31.1—41.9
—ovata Dyer ex Brandis	Meranti sarang punai bukit	5	53.2	49.6—55.5
—pachyphylla Ridl. ex Sym.	Meranti kerukup	5	54.8	50.4—57.6
—palembanica Miq.	Engkabang asu	3	42.3	40.0—46.7
—pallidifolia Ashton	—	1	54.9	—
—parvifolia Dyer	Meranti sarang punai	6	35.6	32.6—40.6
—parvistipulata Heim	Engkabang pinang bersisek	6	45.5	41.2—49.3
—pauciflora King	Engkabang cheriak	7	46.3	43.7—52.4
—pilosa Ashton	Kawang bulu	4	32.4	28.2—39.0
—pinanga Scheff.	Meranti langgai bukit	5	33.0	29.0—38.7
—platycarpa Heim	Meranti paya	5	47.5	45.7—49.1
—platyclados V. Sl. ex Foxw.	Meranti bukit	5	50.2	45.2—54.5
—praestans Ashton	—	2	46.1	41.2—50.9
—pubistyla Ashton	Meranti bulu merah	1	46.8	—
—quadrinervis V. Sl.	Meranti sudu	6	41.2	33.8—43.1
—retusa Meijer	Meranti daun tumpul	3	35.6	33.6—38.9
—rubella Ashton	Meranti laut puteh	4	39.7	36.1—43.3
—rubra Ashton	Meranti merah kesumba	7	39.2	35.9—45.6
—rugosa Heim	Meranti buaya hantu	5	46.5	42.2—52.8
—sagittata Ashton	Meranti luang	3	37.0	35.6—39.0
—scaberrima Burck	Meranti paya bersisek	5	42.2	38.4—45.6
—scabrida Sym.	Meranti lop	6	45.5	41.9—48.1
—slooteni Wood ex Ashton	Meranti kepong kasar	5	51.1	45.9—55.9
—smithiana Sym.	Meranti rambai	5	35.4	31.2—39.3
—stenoptera Burck	Engkabang rusa	3	42.9	41.0—45.7
—teysmanniana Dyer	Meranti lilin	5	42.3	39.1—46.9
—uliginosa Foxw.	Meranti buaya	5	45.1	41.5—47.8
—venulosa Meijer	Meranti tangkai panjang padi	6	50.3	44.0—55.5
Shorea (22 spp.)	SELANGAN BATU(BALAU)GROUP			
—atrinervosa Sym.	Selangan batu hitam	2	61.8	60.6—63.0
—biawak Ashton	Resak biawak	2	64.0	62.4—65.7
—brunnescens Ashton	Selangan batu tinteng	6	63.1	59.7—67.1
—crassa Ashton	Selangan batu daun tebal	4	66.9	63.0—72.4
—domatiosa Ashton	Selangan batu lobang idong	6	65.4	62.4—68.6
—exelliptica Meijer	Selangan batu tembaga	1	64.9	—
—flava Meijer	Selangan batu kuning	5	67.3	64.9—70.5
—foxworthyi Sym.	Selangan batu bukit	3	64.5	63.7—65.5
—geniculata Sym. ex Ashton	Upun penyau	1	61.2	—
—glaucescens Meijer	Selangan batu daun nipis	6	57.5	53.0—63.0
—havilandii Brandis	Selangan batu pinang	3	70.3	68.6—72.4
—hypoleuca Meijer	Selangan batu kelabu	2	64.0	58.7—69.3
—inappendiculata Burck	—	2	67.0	65.3—68.6
—isoptera Ashton	Selangan batu main bulu ayam	4	62.9	62.4—63.7
—ladiana Ashton	Selangan batu kilat	1	68.5	—
—laevis Ridl.	Kumus	6	61.5	59.3—66.1
—lunduensis Ashton	—	1	58.9	—
—maxwelliana King	Kumus hitam	5	65.3	59.3—69.9
—obscura Meijer	Selangan batu padi	4	66.5	64.3—72.4
—scrobiculata Burck	Selangan batu zang	1	64.5	—
—seminis (De Vr.) V. Sl.	Engkabang terendak	5	58.8	56.8—63.0
—superba Sym. ex Wood.	Selangan batu tulang ikan	5	63.9	61.2—66.8

TABLE 2 THE DENSITY OF THE DIPTEROCARP TIMBERS OF SARAWAK—*continued*

Botanical Name	Local or Vernacular Name	Number of Trees	Density—lb. per cu. ft. (at 12% m.c.)	
			Mean	Range
Shorea (7 spp.)	WHITE MERANTI GROUP			
—agami Ashton	Meranti puteh timbul	6	39.4	36.2—43.7
—bracteolata Dyer	Meranti pa'ang	4	46.9	42.1—50.0
—cordata Ashton	—	1	39.3	—
—lamellata Foxw.	Meranti lapis	1	47.0	—
—ochracea Sym.	Raruk	4	39.0	38.1—41.8
—resinosa Foxw.	Meranti belang	1	39.5	—
—virescens Parijs	Meranti sulang sulang	4	36.3	32.5—39.4
Shorea (20 spp.)	YELLOW MERANTI GROUP			
—acuminatissima Sym.	Lun runching	3	45.0	34.3—53.5
—angustifolia Ashton	Damar hitam bukit	5	49.0	40.4—54.7
—collaris V. Sl.	Lun kelabu	1	44.3	—
—cuspidata Ashton	Lun runching padi	1	44.9	—
—dolichocarpa V. Sl.	Damar hitam gondol	6	55.5	50.5—59.9
—faguetiana Heim	Lun siput	6	41.0	34.3—44.3
—faguetioides Ashton	Damar hitam daun nipis	7	45.9	43.4—48.7
—gibbosa Brandis	Lun gajah	4	45.5	41.8—49.7
—hopeifolia (Heim.) Sym.	Lun siput jantan	4	46.5	43.7—48.7
—iliasii Ashton	Lun siput daun besar	6	41.6	38.0—44.9
—induplicata V. Sl.	Lun puteh	1	37.4	—
—longiflora (Brandis) Sym.	Damar hitam paya	2	44.6	42.4—46.8
—macrobalanos Ashton	Engkabang melapi	1	39.9	—
—mujongensis Ashton	—	1	54.3	—
—multiflora (Burck) Sym.	Damar hitam	6	42.3	38.5—46.6
—obovoidea V. Sl.	—	2	35.6	34.3—36.8
—patoiensis Ashton	Damar hitam padi	6	44.4	40.6—48.7
—resina-nigra Foxw.	Lun meranti	5	39.2	38.1—40.6
—subcylindrica V. Sl.	—	3	46.7	44.9—49.1
—xanthophylla Sym.	Lun barun	2	40.5	39.9—41.2
Upuna (1 sp.)				
—borneensis Sym.	Penyau	5	64.5	60.1—70.4
Vatica (21 spp.)	Resak			
—badiifolia Ashton	—	1	61.3	—
—borneensis Burck	Resak kemudi	1	70.5	—
—brunigi Ashton	—	1	59.3	—
—coriacea Ashton	Resak daun tebal	2	70.7	66.5—74.9
—dulitensis Sym.	Resak tiong	4	54.4	52.1—57.9
—endertii V. Sl.	—	2	51.5	51.2—51.8
—globosa Ashton	—	2	60.7	57.5—63.8
—granulata V. Sl.	Resak ranting bersisek	5	52.8	50.2—57.8
—havilandii Brandis	Resak degong	3	55.7	53.7—57.4
—maingayi Dyer	Resak lidi	1	56.8	—
—mangachapoi Blanco	Resak julong	5	59.3	55.5—67.4
—micrantha V. Sl.	Resak hijau	5	58.3	55.5—63.3
—nitens King	Resak daun panjang	5	57.7	53.4—64.7
—oblongifolia Hook f.	Resak membangan	5	52.8	48.4—55.5
—odorata (Griff) Sym.	Resak runting kesat	5	49.1	46.0—52.9
—papuana Dyer	—	2	57.4	53.6—61.1
—rynchocarpa Ashton	—	2	51.3	49.9—52.7
—sarawakensis Heim	Resak daun besar	3	47.8	44.5—55.8
—umbonata (Hook f.) Burck	Resak ayer	5	46.8	43.7—51.0
—venulosa Bl.	Resak letop	3	45.7	42.8—48.5
—vinosa Ashton	Resak tangkai ungu	3	58.1	54.4—61.8

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